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ECOLOGICAL STUDIES ON VECTORS OF MALARIA, JAPANESE ENCEPHALITIS AND FILARIASIS IN RURAL AREAS OF WEST JAVA

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Penangkapan rutin nyamuk dewasa dilakukan dua kali sebulan selama 1 jam pada waktu senja pada badan kerbau, babi dan manusia dan juga dikerjakan penangkapan dengan light trap. Daerah penangkapan meliputi satu daerah dataran rendah Jakarta (semi urban) dan empat daerah pedalaman di Jawa Barat yang ekologinya berbeda-beda dan dimana sawahnya 2 kali panen dalam satu tahun. Penangkapan nyamuk satu malam penuh dari jam 18.00 – 16.00 dikerjakan disalah satu daerah pedalaman tersebut. Kira-kira 90.000 specimen dari 27 species nyamuk telah ditangkap antara bulan Juni 1973 sampai bulan Juli 1974. Penangkapan pada badan binatang dan manusia menghasilkan keterangan-keterangan yang berguna, mengetahui kepadatan musiman dari vektor malaria, Japanese encephalitis dan filaria.

A. aconitus adalah satu Anopheline yang terdapat dalam jumlah banyak menggigit manusia dan kepadatan yang tinggi terdapat didaerah pegunungan dimana sawahnya bertingkat-tingkat (terrace). Di Jakarta dan didaerah yang sawahnya datar nyamuk ini praktis tidak diketemukan. Puncak kepadatan dari species ini berhubungan dengan musin padi yaitu pada bulan Mei dan Juni, dan pada penangkapan satu malam penuh dengan umpan manusia nyamuk ini terdapat dalam jumlah banyak pada waktu-waktu sebelum tengah malam.

Cu. tritaeniorrhynchus, Cu. gelidus, Cu. fuscocephalus dan Cu. vishnui menunjukkan kecenderungan senang terhadap manusia dan babi. Untuk Cu. tritaeniorrhynchus kepadatan dalam jumlah banyak diseluruh kelima daerah penelitian. Puncak kepadatan nyamuk-nyamuk tersebut sangat pendek yaitu beberapa hari sesudah panen. Cu. vishnui lebih senang menggigit manusia bila dibandingkan species lainnya. Di Jakarta terdapat vektor Japanese encephalitis dalam jumlah yang cukup banyak sehingga kemungkinan terjadi penularan didaerah tersebut lebih besar terutama didaerah dimana diketemukan banyak peternakan babi. Dua species lainnya yang banyak menggigit manusia adalah Cu. bitaeniorrhynchus dan M. uniformis.

There are four main mosquito-borne diseases of particular interest to health authorities in Indonesia: malaria, filariasis, dengue haemorrhagic fever (DHF) and Japanese encephalitis (JE). The WHO Vector and Rodent Control Research Unit (VRCRU) is carrying out studies in Jakarta on *Aedes aegypti,* the primary vector of DHF, and also *Culex fatigans,* the main vector of Bancroftian filariasis. Hence, the main purpose of the investigation described herein, made between June 1973 and July 1974, was to obtain information on the ecology of known and potential vectors of malaria, JE and, to a lesser extent, rural filariasis, in one semi-urban and four rural localities of West Java.

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GENERAL INFORMATION

Review of vectors in Indonesia: A brief review is given in the following section to provide some information one those species previously implicated as vectors in Indonesia.

Vectors of malaria: In Java, it is well known that *Anopheles aconitus* is an important vector of malaria in inland areas and *An. sundaicus* in coastal regions, whereas *An. maculatus* has been regarded as being important in hilly areas (Covell, 1944: Sundararaman et al., 1957). As expected, *An. sundaicus* was not encountered in this study, although *An. barbirostirs*, a suspected vector in Sulawesi, occurred in low numbers.

Vectors of JE: Recently, considerable evidence has been obtained, mainly through cooperative efforts of the Indonesian Ministry of Health and the United States Naval Medical Research Unit No. 2 (NAMRU-2), that JE occurs in West Java. In the Kapuk area of Jakarta (briefly described below), the virus has been isolated from *Culex tritaeniorhynchus* (Van Peenen et al., 1974) a) and also from *Cu. gelidus* near Boger (Van Peenen et al., 1975). A high prevalence of haemagglutination-inhibiting (HI) antoboides against JE virus has been found in slaughterhouse pigs at Kapuk (Koesharjono et al., 1973) and sero-conversion has occurred in sentinel pigs (Van Peenen et al., 1974 b).

Moreover, hospitalized cases of suspected JE have been recognized in Jakarta (Kho et al., 1972) and Bandung. Gratz (1973) has pointed out that ecological zones such as Kapuk may provide unusually favourable conditions for certain vector species to establish themselves at high densities, hence posing a considerable thereat to human health. The four most important JE vectors in Asia, i.e. the two above species and *Cu. vishnui* and *Cu. fuscocephalus* were obtained in our collections.

Vectors of filariasis: Some time ago, *Mansonia indiana* was implicated as an important vector of filariasis due to *Brugia malayi* west of Jakarta near Kapuk (Lie et al., 1960). Although this species was not ecnountered, *M. uniformis* was abundant at our Kapuk study site. In addition to *An. barbirostris*, an efficient vector of *B.malayi* in Sulawesi (Partono, et al., 1972), we found *Cu. bitaeniorhynchus* to be quite abundant.

This species was shown to be a vector of *Wuchereria bancrofti* in rural West Irian by Bonne-Wepster (1956), and her surprising observation that *Cu. bitaeniorhynchus* bit man indiscriminately also was made in one of our study sites. *Cu. fatigans* was rare except at Kapuk, but the densities were much lower than in the urban study sites presently under investigation. Lie (1970) has reviewed the present knowledge on the distribution of filariasis in Indonesia and its known vectors. Recently, Lien et al. (1975) has suggested that *M. uniformis* is a vector of *Brugia malayi* in endemic areas of North Sumatera.

Description of study areas: Each of the five sites normally had at least 300 ha of rice fields, 500 houses, 3000 inhabitants, nearby forests partially surrounding the ricefields and five or more buffalos. Two of the five ricefield sites had domestic pigs.

One rice growing site, Kapuk, has a large pig slaughterhouse, and live animals are transported from as far away as Jogyakarta and Bali. It is semi-urban, open and located in west metropolitan Jakarta on the city's outer fringes. The four remaining rice-growing sites are not near large cities and only Iwul, 15 km north of Bogor, had domestic pigs, although wild ones are known to occur in the forest above the Ciloto resort area. As shown on the next page, each of the five rice-growing study sites, despite the relatively short distance which separates them, are markedly different in respect to elevation and whether flat or terraced ricefields are predominant.

Location of study sites in rural and semi urban areas in West Java.

Study Site	Location	Metres above sea level	Brief description	Predominant type ricefield	Domestic pigs
Kapuk	NW Jakarta suburb 2 km from Java sea	0	semi-urban	flat	yes
Iwul	28 km S Jakarta 15 km N Bogor	120	rural, slightly terraced hilly	terraced	no
Ciloto	63 km SE Jakarta	1250	rural, very hilly	terraced	no
Sukanagalih	68 km SE Jakarta	945	rural, moderately hilly	terraced	no
Ciranjang	84 km SE Jakarta 40 km W Bandung	320	rural, in valley	flat	no

Rice cultural practices: Two crops per year are grown at each of the rice-growing sites. As mentioned, four prominent stages apparently affected the seasonal abundance of certain species: pre-harvest, ready to harvest, post-harvest stubble and rice newly transplanted. Harvesting normally began about six weeks after the pre-harvest stage, whereas transplanting began about six weeks after harvesting commenced.

In general, in the absence of unusually dry seasons, the time of beginning the first and second harvest are fairly constant from year to year. The first harvest ususlly began in May or June in all areas except for April in Ciranjang. The second harvest began in October or November.

We found that the reporting of specific dates for several rice cultural activities could be misleading for the following reasons. Usually village labour is not available in large enough numbers to complete these activities promptly, and the busy harvesting and transplanting periods can last from 8 to 12 weeks. As transplanting becomes dominant, decaying rice stubble from previously harvested fields slowly disappears. It was not uncommon for us to observe in the same locality a few unharvested fields even in the presence of newly transplanted rice.

Agricultural use of pesticides: Applications were observed only at Kapuk and Ciranjang, both being flat areas with rice yields being higher than at the other sites. Diazinon, and occasionally Thiodan, were applied by knapsack sprayer at Ciranjang but endrin at Kapuk. About three pesticide applications can be made between the transplanted and pre-harvest stage. It is our impression that, contrary to findings in Korea (Self et al., 1973), pesticide applications were not frequent enough over large areas to affect mosquito adult density appreciably.

Climate and meteorological information: In general, West Java is green throughout the year, having rainfall every month, but about 80-90 per cent occurs from December through May, with August normally being the driest month and January the wettest. Data obtained from the Jakarta Observatory show that yearly rainfall totalled 1750 mm, being typical to previous years. However, about twice as much rainfall occurred at a high elevation site (Cinapas) located within 8 km of Sukanagalih and Ciloto

The mean temperature at Jakarta is about 26°C with little monthly variation, whereas the mean maximum and minimum temperatures are typically about 30°C and 23°C respectively. The relative humidity is high throughout the year, averaging 78 per cent. The temperature however is considerably lower at Ciloto, with a mean of 21°C and a mean maximum of only 25°C. There, the relative humidity remains high and is similar to Jakarta.

Taxonomic notes: Adult mosquitos were normally identified in the VRCRU laboratory at Jakarta or Ciloto the day after collection.

For larval collections from ricefields, many fourth instars and pupae were reared to the adult stage to facilitate identification. Samples of all identified adult species are available for further study at the VRCRU reference collection at Jakarta.

The keys and illustration by Reid (1968) for anophelines and Bram (1967) for culicines were particularly useful, although other references were also utilized. Ramalingam (1974) lists 60 species with several new records for Java indentified from our study sites and nearby areas. About ine third of those species were of minor importance, and some of them were collected during this investigation, but they are not listed herein.

The larval stages of *Cu. pseudovishnui* were only found at the two high altitude ricefield sites, Sukanagalih and Ciloto, whereas *Cu. vishnui* larvae occurred only at the lower sites. Because the adults of both species are not easily separated, all collected adult speciments of this complex were recorded to species bases on these larval findings. Although larvae of both species were not found to overlap at the same site in this study, Ramalingan (1974) found both larval species in Jakarta, but only *Cu. pseudovishnui* at Ciloto. This therefore suggest that, without further study, these two species cannot always be separated on the basis of altitude. Scalon & Esah (1965), based on adult specimens identified in Thailand, reported both species occuring at the same three locations at elevations ranging from 305 m to 1372 m, but only *Cu. pseudovishnui* occurred above 1372 m.

Because Reuben (1969) considered on taxonomic grounds that *Cu. vishnui* was identical with *Cu. annulus,* the former name has been used herein. Nevertheless, recent investigations in China (Province of Taiwan) and Indonesia treated *Cu. annulus* as a distinct species and not as a synonim of *Cu. vishnui* (Mitchell & Chen, 1973; Van Peenen et al., 1974 a; Dr. J.C. Lien, personal communication). The species referred tto as *Cu. annulus* by Van Peenen et al. (1974 a and c; 1975) in their West Java investigations probably is the same species which we have designated as *Cu. vishnui.* Sirivanakarn (1975) in his treatm of the *Cu. vishnui* complex concluded that Southeast Asian *annulus* can best be co dered either as a subspecies of *vishnui* or geographic infra specific form, and that i best to treat *annulus* only as a form of *vish* without elevating the name *"annulus"*, wh would further confuse the status of this s cies.

We found that the adult stages of *subpictus* and *An. indefinitus* were sometir difficult to separate, and the precision desi in identification was not obtained. Howe the combined density of both species human bait was very low. Also some of *An. peditaeniatus* specimens at Kapuk m have been *An. nigerrimus.* Neither howe are considered important vectors of malaria Indonesia.

METHODS

The adult collecting method (these are cribed below) which obtained the most m quitoes was used for defining the populat peaks. For *Anopheles* and *M. uniformis* was buffalo bait, but for the *Culex* either and human bait or light traps were the m sensitive collecting methods depending species and locality. In general, the p population periods were similar by methods.

Collection of adults from animal and hun bait: Mosquitoes were simultaneously c lected with sucking tubes from buffalo a human bait at each locality from about 18: to 19:45 hours, being about 30 minutes af sunset. Pig bait also was employed at Kap and Iwul. These collections occurred ab every two weeks for 14 consecutive mont although longer collecting intervals sometin were unavoidable.

Two scouts collected mosquitoes off t buffalo in partially open shelters, and also p if present, while two other scouts sat outdo on the verandahs of houses and collect mosquitoes off themselves. These baits w situated at their normal locations within t village and were usually separated by 50 m more.

l night outdoor human bait collections made only at Sukanagalih, the locality n to have the highest density of *An. tus* according to the other collecting ods. About twice a month, three to four alternated throughout the night, with one of them collecting mosquitoes at a time.

ction of adults by light trap: Nozawa light traps (110 volts, 60 wats), made ›saki, Japan, were operated from 18:00 to) hours about twice a month at each growing site. Trap placement depended available sources of electricity. The traps placed 2 m above an open pig pen at ık, at the top of a 5 m high chicken coop wul, and alongside houses at the three · localities. Table 2 shows the hours of operation.

ction of larvae: Short-handled dippers neter 8 cm) were used for collecting e and pupae from ricefields. Collections not made as often as for adults. Two quito scouts worked for about 90 minutes he morning or late afternoon at each ity. Table 6 shows the number of col- ng days and man hours employed.

quito virus pools: Blood-fed *Culex* col- :d mainly from buffalo at Sukanagalih and njang were held for 24 hours or more for ıd digestion and transported alive to the 'arma Virus Laboratory at nearby Bandung HI tests. About one half of the *Cu. eniorhynchus* specimens were obtained ı human bait at Ciranjang, and one pool *Cu. tritaeniorhynchus* (75 specimens) was ıined from pig at Iwul.

)etails of 94 processed pools, representing 2 specimens collected from June 1973 to ruary 1974 are available at RCRU and 'arma. The species processed were *Cu. eniorhynchus*, which comprised 46.8 per : of the specimens, followed by *Cu. bita- rhynchus* (20.5 per cent). *Cu. fusco- cephalus* (17.6 per cent), *Cu. pseudovishnui* (11.5 per cent and *Cu. vishnui* (3.6 per cent).

RESULTS

List of adult species collected: Table 1 shows the total number of female mosquitos collected by all methods. There were 9 species of *Culex*, 13 *Anopheles*, 2 *Mansonia* and 3 *Aedes* totalling 27 species and 9.434 specimens.

These four genera accounted for 65.2 per cent 30.5 per cent, 4.1 per cent and 0.2 per cent of the total captures, respectively. As expected, most specimens were *Anopheles* and *Culex* since the collecting methods favoured these genera.

Table 1 Number of female mosquitos collected by several methods in five localities of West Java from June 1973 to July 1974

Culex		*Anopheles*	
tritaeniorhynchus	35 820	*vague*	22 140
gelidus	8 118	*aconitus*	1 110
fuscocephalus	4 916	*barbirostris*	979
bitaeniorhynchus	4 118	*indenfinitus*	811
pseudovishnui	2 127	*annularis*	724
whitmorei	1 497	*subpictus*	637
vishnui	1 282	*peditaeniatus*	477
fatigans	866	*kochi*	437
sinensis	255	*maculatus*	133
Total	58 999	*tesselatus*	73
		philippinensis	6
Mansonia		*schuffneri*	5
uniformis	3 562	*karwari*	2
Total	3 736	Total	27 534
Aedes		Total species	27
caecus	68	Total specimens:	90 434
lineatopennis	55		
poecilus	42		
Total	165		

Amongst *Culex* spp., *Cu. tritaeniorhynchus* accounted for 60.7 per cent of the total captures, followed by *Cy. gelidus, Cu. fuscocephalus, Cu. bitaeniorhynchus, Cu. pseudovishnui, Cu. whitmorei,* and *Cu. vishnui.* Van Peenen et al. (1974 c) in light trap collections also found *Cu. tritaeniorhynchus* was by far the most abundant *Culex* at three West Java study sites, and also, that *Cu. annulus ("vishnui")* occurred in low numbers.

Table 2 Mean number of female mosquitos per man hour obtained by different collecting methods five ricefield localities of West Java from June 1973 to July 1974

Collecting method and time		Buffalo bait 1845–1945					Pig bait 1845–1945		Human bait 1845–1945					Human bait 1800–0600	Light trap 1800–0600				
Locality : 1 = Kapuk, 2 = Iwul, 3 = Ciloto, 4 = Sukanagalih, 5 = Ciranjang		1	2	3	4	5	1	2	1	2	3	4	5	4	1	2	3	4	5
Man hours of collection[a]		56	62	29	65	58	57	58	58	59	75	64	86	312	312	288	348	276	312
Number of collecting days		28	31	24	31	28	29	29	29	30	43	29	28	26	26	24	29	23	26
Anopheles	*aconitus*	.09	2	2	6	.2	.02	.5	-	.2	.08	1	.3	0.9	.02	.09	.04	.2	.003
	annularis	.3	4	-	.5	.3	.02	.5	.07	.04	-	.09	.02	.03	.9	.1	.01	.05	.03
	barbirostris	1	2	.7	6	5	.09	.6	-	.1	.04	-	.1	.003	.03	.007	.01	.1	.03
	indefinitus	20	1	.3	4	3	.4	.07	.1	.1	-	-	.01	-	.5	-	.008	.01	.003
	karwari	-	-	-	-	-	-	-	-	.04	-	-	-	-	-	-	-	-	-
	kochi	-	.7	.4	5	.6	-	.2	.09	.03	-	-	-	-	-	.003	-	.004	-
	maculatus	-	.2	2	.4	.09	-	.02	-	.03	.03	-	-	.003	-	-	.02	.07	-
	peditaeniatus	3	1	.03	.9	2	.05	.09	.1	.03	-	.2	.2	.003	.05	.007	-	-	.02
	philippinensis	-	.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	schuffneri	-	-	-	-	-	-	.07	-	.02	-	-	-	-	-	-	-	-	-
	subpictus	9	.3	-	-	-	.3	-	-	.03	-	-	.01	-	.3	-	-	-	-
	tesselatus	.4	.03	.03	.4	.2	.02	-	-	.02	-	-	.03	-	.006	.007	-	.004	-
	vagus	30	19	12	191	106	.4	.7	.2	.08	.08	.06	.9	.02	.1	.2	.01	.3	.07
Culex	*bitaeniorhynchus*	.2	.5	1	5	18	-	1	.09	.7	.4	2	22	2	.04	.05	.1	.2	.3
	fatigans	.2	.03	-	.02	-	2	.09	6	.1	.3	.2	.2	-	.8	.06	.003	.2	.01
	fuscocephalus	3	3	6	26	16	.7	3	.2	.3	.1	.2	3	.2	2	.2	.06	1	.7
	gelidus	4	2	.4	1	1	4	3	.05	.1	.01	.03	.01	.01	23	.06	.03	.02	.03
	pseudovishnui	-	-	14	13	-	-	-	-	-	2	2	-	1	-	-	.03	1	-
	sinensis	.02	.9	2	-	-	.04	.9	.09	1	-	-	-	.05	-	.02	-	-	-
	tritaeniorhynchus	48	17	20	26	85	44	49	.9	1	.6	.7	9	1	56	.6	.2	1	.8
	vishnui	.4	2	-	-	1	.3	5	.05	.8	-	-	7	-	.3	-	-	-	.08
	whitmorei	-	8	.6	2	.4	.09	8	.05	.6	-	-	.1	.02	.5	.5	-	.03	.003
Mansonia	*annulifera*	1	.03	-	-	-	.04	-	.9	-	-	-	-	-	.2	-	-	-	-
	uniformis	23	.1	-	-	-	3	.2	17	.05	-	-	.02	-	4	-	-	-	-
Aedes	*caecus*	-	.4	-	-	-	-	.5	-	.2	-	.03	-	-	-	-	-	-	-
	lineatopensis	.02	.03	-	.3	.5	-	-	-	-	-	-	.01	-	.006	-	-	-	-
	poecilus	-	.3	-	-	-	-	.4	-	.4	-	-	-	-	-	-	-	-	-

[a] Light trap data refer to hours of operation.

The most abundant *Anopheles* was *An. vagus*, representing 80.4 per cent of the total captures, followed by *An. aconitus* (4.0 per cent). *An. barbirostriss*, and *An. annularis* were similar in abundance to *An. aconitus*, whereas *An. maculatus* was relatively rare and represented only 0.5 per cent of the captures.

The most abundant species among the remaining genera were *M. uniformis* and *Ae. caecus.*

Mean adult density according to locality and collecting method (Table 2)

Anopheles: The one-hour buffalo bait collections for the 14 month study provided a convenient method for determining differences in abundance among species and localities. Sukanagalih had the highest overal Anopheli density, and this was mainly attributed to tl abundance of *An. vagus* on buffalo. With *A aconitus,* the density in human bait at Suk nagalih was 3 to 12 times higher than at thr other localities. Ciloto had the highest densi of *An. maculatus,* but this species was n found at Kapuk.

Culex: In general, the buffalo bait collectio also were a convenient method for dete mining the differences in abundance. Howeve *Cu. tritaeniorhynchus, Cu. gelidus* and *C whitmorei* showed a preference for pig an *Cu. bitaeniorhynchus* for humans. *Cu. vishni* also preferred pig, but man if pigs wei absent. The light traps were highly effectiv *ı. tritaeniorhynchus* or *Cu. gelidus* were ıptured in one trap night.

Kapuk and Ciranjang had the highest *Culex* ınsities, but considerable numbers of *Cu. itaeniorhynchus* and *Cu. pseudovishnui* ;curred at the two most hilly localities. *Cu. taeniorhynchus* was very abundant at Cinjang, and as many as 90 females per man ͻur were collected of human bait. *Cu. fusco- ·phalus* was ubiquitous like *Cu. tritae- orhynchus* but at densities seven times wer.

'ansonia: M. uniformis was quite abundant ı buffalo, human and, to a lesser extent, pig ıit at Kapuk. It was practically absent from l other localities.

edes: Ae. caecus and *Ae. poecilus* fed on ıffalo, pig and human bait at low densities Iwul, the latter species a vector of *W. 'ancorfti* in the Philippines. *Ae. lineatopennis* ;curred on buffalo bait at all localities :cept Ciloto. Scanlon & Esah (1965) men- ͻned that this species fed readily on do- estic animals and was common in agri- ıltural areas.

Periods of high and low density of the most prevelent species (Table 3, 4)

Anopheles: With *An. vagus,* the dates of peak densities varied considerably among the five study localities. Abundance was not related to one specific stage of rice development, or rainfall, and this perhaps accounted for its high population density which sometimes lasted for several months.

An. aconitus was fairly abundant only at the two most hilly localities and at Iwul, each having terraced ricefields; the densities were negligible in the flat Ciranjang valley and Kapuk plain area sites. The peak densities in the three terraced localities occurred in May or June, when the first rice harvest began. A second peak also occurred in October at the time of the second rice harvast at Sukanagalih. Each locality had low densities during August, a month noted for low rainfall and fields of short, young rice.

An. barbirostris, An. annularis and *An. maculatus* were all found at low densities during January, a period of high rainfall and

ıble 3 Period of high and low density of the most prevalent anopheles species in five ricefield lo- lities of West Java from June 1973 to July 1974. (Collections made from buffalo bait from 18:45 to ı:45 hours).

ocality	High density Period	Mean No. Females/Man Hour	Low density Period	Mean No. Females/Man Hour
		An. vagus		
ɹk	September, January	150	May - July -	6
	January, June	43	February - April	10
:o	August, September	32	December - March	.6
ınagalih	August - October	406	February - May	107
ıjang	April - June	223	August - October	11
		An. aconitus		
	June	7	August - February	.5
o	May	7	August - March	.3
nagalih	May, October	16	July - September	2
		An. barbirostris		
nagalih	October	54	December - March	2
ıjang	September, March, July	11	October - January	.7
		An. annularis		
	October - December	10	January - May	.9
		An. maculatus		
o	June, July	6	August - May	.7

Table 4. Period of high and low density of the most prevalent Culex and mansonia species in five ricefield localities of West Java from July 1973 to July 1974

Locality	Collecting Method [a]	High Density	Mean No. Females/Man Hour	Low Density Period	Mean No. Females/Man Hour
		Cu. tritaeniorhynchus			
Kapuk	Light trap	July, Oct., Feb.	134	Apr. - Jun.	23
Iwul	Pig	May - July	81	Oct., Nov.	12
Ciloto	Buffalo	July, August	46	Dec. - Apr.	4
Sukanagalih	Buffalo	October	64	Feb., Mar.	2
Ciranjang	Buffalo	April, October	218	June - Aug.	21
		Cu. bitaeniorhynchus			
Sukanagalih	Human [b]	July, August	4	Apr., - Jun.	.3
Ciranjang	Human	June	73	Feb., Mar.	.2
		Cu. fuscocephalus			
Kapuk	Light trap	July, December	6	Jan. - Jun.	9
Sukanagalih	Buffalo	June	73	Feb.	2
		Cu. pseudovishnui			
Ciloto	Buffalo	April, July	57	Jan., Feb.	2
Sukanagalih	Buffalo	June, Sep., Oct., Dec.	27	Feb., Mar.	3
		Cu. vishnui			
Iwul	Pig	September	13	June	2
Ciranjang	Human	April	20	Nov.	1
		Cu. gelidus			
Kapuk	Light trap	February, March	108	Aug. - Jan.	5
		Cu. sinensis			
Iwul	Human	April	6	July - Mar.	.7
		Cu. whitmorei			
Iwul	Pig	September	25	May, June	3
		M. uniformis			
Kapuk	Buffalo	September - November	55	Dec. - Mar.	10

[a] Collections made from 1845 to 1945 hours otherwise noted. The light traps were operated all night.
[b] All night collection from 1800 to 0600 hours.

recently transplanted rice. The peak density of *An. barbirostris* occurred at Sukanagalih in October, and the *An. maculatus* peak at Ciloto in June and July. Although the October peak of *An. barbirostris* on buffalo at Sukanagalih greatly exceeded that of *An. aconitus*, the former species was extremely rare on human bait.

Culex: At Kapuk, the peak *Cu. tritaeniorhynchus* density normally occurred after harvesting in July and October, whereas *Cu. gelidus* had one distinct peak in February and March. Elsewhere, abundant *Cu. tritaeniorhynchus* and also *Cu. fuscocephalus* populations were related to the harvesting period and the availability of decaying rice stubble for larval breeding; but high densities of *Cu. pseudovishnui*, *Cu. whitmorei* and *Cu. sinensis* occurred at other times.

Cu. vishnui was most abundant at Iwul during September and at Ciranjang during April. The *Cu. bitaeniorhynchus* peaks at Sukanagalih and Ciranjang were related to the second rice crop, namely the presence of young short rice with green algae that provided ideal larval breeding conditions between June and August. Senior-White (1926) and others have recognized the importance of green algae for larval development of *Cu. bitaeniorhynchus.*

Mansonia: At Kapuk, the *M. uniformis* peak on buffalo occurred from September through November when rainfall was relatively low. The densities were the lowest, but nevertheless appreciable, during the months of heaviest rainfall.

All night human bait collections with time of feeding (Table 5)

Table 5 Time of feeding of several species on human bait in 26 all night outdoor collections (312 man hours) at Sukanagalih, West Java, from June 1973 to July 1974

Species	Mean number females per man hour at hour beginning												Mean per man night
	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	
An. aconitus	1.0	1.5	.8	2.0	.8	.9	.9	.7	.7	.7	.4	.3	10.7
Cu. bitaeniorhynchus	1.4	2.4	2.5	2.8	3.9	2.5	1.8	2.1	1.8	1.0	1.2	.3	23.7
Cu. pseudovishnui	.9	.8	1.3	1.4	2.9	2.2	2.0	1.5	1.4	1.2	.3	.2	16.3
Cu. tritaeniorhynchus	.9	.6	1.3	1.4	1.7	1.3	1.2	.8	.8	.9	.6	.2	11.7

Anopheles: An. aconitus was the only anopheline atracted to human bait in appreciable numbers. For the 26 all night collection at Sukanagalih, the mean number of females per man night outdoors for *An. aconitus* was 10.7 compared to only about 0.3 for *An. vagus* and *An. annularis*, the next most abundant species. In East Java, Chow et al. (1960) found that about three times as many *An. aconitus* fed outdoors than indoors, and in Central Java similar trends are being noted (umpublished VRCRU data). Therefore the mean indoor biting density at Sukanagalih was probably lower than the outdoor density.

An. aconitus was active throughout the night, with about 50 per cent of the feeding occurring between 18:00 and 22:00 hours and 74 per cent before midnight. The peak of the population was associated mainly with the rice harvest, and occurred during May, June and July with the mean number per man night being 24 or 2 per men hour. The largest number obtained in one collection was 55 females per man night in May, being about one-third the peak March-April density VRCRU recently found near Semarang, Central Java. The low density period was August and September (3 per man night), agreeing with the seasonal trend on buffalo. However, unlike buffalo, no October peak on human was observed, and this was perhaps due to unfavourable weather conditions during the later collections.

Chow et al. (1960) obtained a yearly mean of 8 females per man night in East Java, with the outdoor collection being made only during the first 15 minutes of each hour. They also found that the majority of the feeding on human bait occurred before midnight, although the peak on buffalo was after midnight.

Culex: Cu. bitaeniorhynchus and two other species were also abundant on human bait at Sukanagalih, with 71 per cent of the feeding occurring before midnight. For *Cu. pseudovishnui* and *Cu. tritaeniorhynchus,* densities were the highest from June through August, and for *Cu. bitaeniorhynchus,* July and August. For each species, the mean number of females per man night during those peak perios was 36. Despite its abundance on buffalo, *Cu. fuscocephalus* was rarely encountered in these all night human bait collections, with the 14 month mean being 1.8 per man night.

The lowest densities of *Cu. tritaeniorhynchus* and *Cu. pseudovishnui* (2 per man night) occurred during March, but in April and May for *Cu. bitaeniorhynchus* (4 per man night). These periods of low *Culex* density, as found with buffalo, were associated with the absence of post harvest rice stubble for *Cu. tritaeniorhynchus* and *Cu. pseudovishnui* larvae and newly transplanted rice with algae for *Cu. bitaeniorhynchus* larvae.

Host preference (Table 6)

Should it not be possible to make precipitin tests, Reid (1968) indicated that useful information on host preference can still be obtained if collections are made simultaneously in different baits, which are separated by 20-50 m and located at their normal situation within the collecting area. In this study the results of the one-hour collections made simultaenously on buffalo and man in each of the five ricefield localities, involving 266 man hours for each host, have been combined and presented in Table 6. These data for 20 species are arranged according to those feeding the most times in human bait. The number of vector species coming to bite man are obviously an important factor in understanding the dynamic of disease transmission.

Table 6 Comparison of collections made simultaneously on human and buffalo bait from 1845 to 1945 hours in five ricefield localities of West Java from June 1973 to July 1974

Species collected during 266 man hours at Kapuk, Iwul, Ciloto, Sukanagalih and Ciranjang	Number from human bait	Number from buffalo bait	Total	% on human bait
Cu. bitaeniorhynchus	1 523	1 436	2 959	51.5
M. uniformis	815	1 227	2 042	39.9
Cu. vishnui	456	210	666	68.5
Cu. fatigans	320	14	334	95.8
Cu. fuscocephalus	225	3 100	3 325	6.8
Cu. pseudovishnui	192	1 338	1 530	12.5
Cu. tritaeniorhynchus	171	6 152	6 323	2.7
An. aconitus	101	581	682	14.8
Cu. sinensis	76	112	188	40.4
An. vagus	75	19 212	19 287	.4
Cu. whitmorei	44	602	646	6.8
An. peditaeniatus	33	402	435	7.6
An. annularis	13	255	268	4.9
An. barbirostris	13	862	875	1.5
An. indefinitus	13	1 651	1 664	.8
Cu. gelidus	13	442	455	2.9
An. masculatus	3	83	86	3.5
An. subpictus	3	584	587	.5
An. tesselatus	3	63	66	4.5
An. kochi	2	370	372	0.5

By far the most abundant species taken in human baits were *Cu. bitaeniorhynchus* and *M. uniformis*, the former species even preferring man to buffalo. Although the overall density of *Cu. vishnui* was low in comparison to other *Culex* species, it was more abundant on man than *Cu. fuscocephalus*, *Cu. pseudovishnui* or *Cu. tritaeniorhynchus*. It was highly anthrophilic at Ciranjang.

In China (Province of Taiwan), the biting [illegible] through September averaged 118 females per man hour as opposed to even higher rates on buffalo (Mitchell & Chen, 1973). It therefore seems quite possible that man could receive a considerable number of bites in localities where this species is abundant.

The numbers of *Cu. gelidus* biting man were low in our study, but its potential for JE disease transmission is nevertheless considerable due to its preference for pig. At the study sites with pig (Kapuk & Iwul), *Cu. tritaeniorhynchus*, *Cu. gelidus*, *Cu. whitmorei* and even *Cu. vishnui* all showed a preference for pig (over 50 per cent of the bites) in comparison to buffalo and human bait. These species, with the possible exception of *Cu. whitmorei*, must be considered as potential vectors of JE in Indonesia, aling with *Cu. fuscocephalus* which also readily bites pig. *Culex patigans* showed, as expected, a marked preference for man (95 per cent of the bites), but its overall density was low.

The numbers of anophelines biting human bait were considerably lower than those of *Culex*. The most abundant species taken on man was *An. aconitus* followed by *An. vagus*; none of the other anophelines were found in large enough numbers to consider them as important malaria vectors. *An. vagus* was attracted to buffalo in large numbers, but only 0.4 per cent of the total buffalo-man collections had fed on man. Even with high densities, this species is nor regarded here as a serious vector; the possibilities for two blood meals on man appear remote in comparison to *An. aconitus*, which also is mainly zoophilic.

The overall density of *An. aconitus* was low, but 14.8 per cent preferred human bait. Precipitin tests on 359 bloodmeals of *An. aconitus* collected outdoors in East Java showed that 17.3 per cent fed on man, whereas only 2 of 743 (0.3 per cent) *An. vagus* were positive for man (how et al., 1960).

An. aconitus had a marked anthropophily over all other anophelines in our study, and this also was the case among 7 other anophelines in the above East Java study.

Table 7 Numbers of anopheles and culex larvae and pupae collected by dipping in ricefields in five localities of West Java from July 1973 to May 1974

Area	Total collecting days [a]	Total man hours	Total *Anopheles* collected	(*Anopheles*) Mean No. per man/hour			Total *Culex* collected	(*Culex*) Mean No. per man/hour		
				I–II instars	III–IV instars	pupae		I–II instars	III–IV instars	pupae
Kapuk	9	30	384	6.3	6.0	0.5	8 334	134.1	137.4	6.3
Iwul	11	39	215	3.5	1.8	0.2	1 452	18.3	15.5	3.4
Ciloto	21	29	60	0.7	1.3	0.07	3 579	37.3	76.4	9.7
Sukanagalih	19	48	1 766	5.8	25.9	5.1	4 771	32.7	48.9	17.8
Ciranjang	18	66	192	1.7	1.1	0.1	6 857	35.2	51.2	17.5

[a] Collections at Kapuk and Iwul were not made after January 1974 and at Sukanagalih after April 1974.

Larval collections in ricefields (Table 7,8)

The largest numbers of anopheline larvae and pupae were collected at Sukanagalih, being also the locality with the most anopheline adultas (Table 7). At Kapuk, the density of early instar anophelines was similar to Sukanagalih, yet the pupal counts were 10 times lower. At Ciranjang very few pupae were found, indicating that the high adult densities of *An. vagus* were at least partly derived from other sources. The immature stages of *Culex* spp as expected, occurred in much greater numbers than the anophelines.

Eleven *Anopheles* and eight *Culex* species were collected from ricefields, with *Cu. sinensis, An. philippinensis* and *An. schuffneri* being obtained only in the adult stage (Table 8). *An. aconitus* larvae were not found at Kaupk and Ciranjang, where very low adult densities also occurred. High larval densities of *An. vagus, Cu. gelidus, Cu. pseudovishnui, Cu. tritaeniorhynchus,* and *Cu. vishnui* were found in post-harvest rice stubble at certain localities. Although the adult collections revealed *Cu. bitaeniorhynchus* was more abundant at Ciranjang than Ciloto, the density of late instar larvae was highest at Ciloto. This apparent discrepancy may have been due to sampling procedures or more predation on pupae at Ciloto where pesticide applications are infrequently made. *Cu. vishnui* larvae were fairly abundant at Kapuk, but the adult density was found to be low.

Virus pools: One pool of *Cu. vishnui* obtained from buffalo bait at Ciranjang in July 1973 caused marked abnormal signs in suckling mice eight days after inoculation. Further passages however were inconclusive. The other 93 processed pools all were negative.

In the future, mosquitos should be held longer to allow for complete blood digestion and more collections made from hosts other

Table 8 Mean density per man hour of third and fourth instar larvae of different mosquito species found breeding in ricefield in five localities of West Java from July 1973 to May 1974

Locality : Total man hours [a]	Kapuk 30	Iwul 39	Ciloto 29	Sukanagalih 48	Ciranjang 66
Anopheles aconitus	-	1.0	0.1	0.1	-
annularis	0.3	-	-	-	-
barbirostris	-	0.2	0.5	1.3	0.08
indefinitus	-	-	-	-	0.07
karwari	-	0.08	-	-	-
kochi	-	-	0.05	0.2	-
maculatus	-	-	0.05	-	-
peditaeniatus	-	0.3	0.05	-	-
subpictus	0.3	-	-	-	-
tesselatus	-	-	0.05	-	-
vagus	5.4	0.2	0.5	24.3	0.9
Culex bitaeniorhynchus	0.02	6.5	71.5	22.7	27.5
fatigans	0.1	-	-	-	-
fuscocephalus	27.2	-	0.5	3.1	4.8
gelidus	10.2	-	-	-	-
pseudovishnui	-	-	0.9	10.3	-
tritaeniorhynchus	72.3	8.1	3.4	12.8	12.3
vishnui	25.4	0.02	-	-	-
whitmorei	2.2	0.9	-	-	-

[a] See Table 7 for futher collecting details.

than buffalo. The information obtained on this study on species abundance, according to time, locality and host, should be useful in further virus isolation attempts.

DISCUSSION

Several known or potential vectors were abundant at each study locality at certain times of the year. The vector-borne disease potential in these and similar type localities might be further elucidated epidemiologically by determining the number of presumed or confirmed cases of human disease.

Malaria vectors: In hilly areas, *An. aconitus* occasinally was found in fair numbers on human bait, but all other anophelines always showed either marked zoophily. *(An. vagus, An. subpictus, An. indefinitus, An. annularis, An. barbirostris)* or low population density *(An. peditaeniatus, An. kochi, An. maculatus, An. tesselatus).* With two feedings required on man to transmit malaria, *An. aconitus* appeared more likely than any other species of fulfilling that requirement. We found that the time *An. aconitus* preferred to feed on human bait in all night collections, and its degree of anthropophily, and the correlation of its peak density to rice harvest were similar to findings in East Java (Chow et al., 1960).

Although *An. aconitus* is considered here to be possibly the only anopheline involved in malaria transmission at our study sites, it was practically absent in the plain and valley locations. It may be assumed that at such places, malaria is not a problem, at least at the Jakarta plain site. Recognizing the areas having negligible densities of a known vector, and knowing the reasons for it, obviously can be valuable information in malaria control strategy, particularly if other species are not playing a role in transmission.

An. aconitus, as previously mentioned, was more commonly found in hilly locations with terraced ricefields, and the site with the highest density had an elevation of 945 m with considerable rainfall. Terraced ricefields in the hilly areas are frequently flushed with cool, clear water flooding down from higher elevations, and *An. aconitus* may very well prefer this situation to the stagnant, warmer water which often accumulates in ricefields in the flatter areas. The hilly areas may also provide more suitable ourdoor resting places, particularly along shaded stream banks close to the water.

Further information on the distribution and abundance of *An. aconitus* in predominantly flat and terraced ricefield areas away from the coast is very much needed. Relating densities to altitude alone may be misleading, because terraced fields can occur at relatively low elevations (Iwul) and flat fields in the valleys at relatively high elevation (Ciranjang). It would be useful to know whether *An. aconitus* normally occurs at low density levels in these inland areas which are flat and whether or not this is associated with few or no malaria cases.

JE vectors: Because several collecting methods were simultaneously employed, certain abundant populations were detected which might have been missed of only one method, such as light traps, had been used. Those species found to have the greates tendency to feed on both pig and man were those previously implicated in JE transmission in Indonesia or other Asian countries, namely, *Cu. tritaeniorhynchus, Cu. gelidus, Cu. fuscocephalus* and *Cu. vishnui.*

The latter species had the lowest overall density but it attacked man in larger numbers than other species. Studies presently being conducted by VRCRU in Central Java near Semarang are showing *Cu. vishnui* to be one of the most abundant culicines biting man in all night collections. The peak densities of these species in West Java normally occurred after the rice harvest, being mainly attributed to larval breeding in stagnant water amongst decaying rice stubble. However, abundant adult populations also occurred on the apparent absence of this factor.

Large numbers of *Cu. tritaeniorhynchus* were found at all locations, but *Cu. gelidus* only at the Jakarta plain site, *Cu. fuscocephalus* at the same hilly site where *An. aconitus* was most abundant, and *Cu. vishnui* at iranjang valley and at Iwul. In contrast to *In. aconitus*, the greates numbers of potential E vectors occurred at the plain and valley tes.

Immense numbers of *Cu. tritaeniorhynchus* r *Cu. gelidus* were occasionally captured on ie outer fringe of Jakarta, and this finding is milar to the situation in Korea. There, large umbers of vectors were not mainly attributed) ricefield breeding, and the highest density f *Cu. tritaeniorhynchus* did not occur in ıral areas but at the outer fringe of large ties where most of the JE cases occurred ielf et al., 1973 b). There was evidence that oth of the above species also bred, in addi- on to ricefields, in vacant grassy fields and ooded vegetable plots at Jakarta. In Indo- sia, risk to JE infection would also seem to greatest in or near large cities, where pig rmers would benefit by close proximity to tential markets.

lariasis vectors: The two species biting man the largest numbers in this study were *Cu. 'aeniorhynchus* and *M. uniformis.* The latter ecies was abundant only at Jakarta, and anlon & Esah (1965) did not find it above 5 m in Thailand. Both of these species are ge vicious biters, and are quite a nuisance art from potential disease transmission. The ghest densities of *Cu. bitaeniorhynchus* curred at the Ciranjang valley site, and this s attributed to extensive fields of newly nsplanted rice which ultimately produced a ge surface layer of filamentous green algae *irogyra)* in relatively stagnant water.

Further studies involving dissections of ese two species for filarial parasites, in njunction with blood surveys to determine crofilaria rates in humans, are warranted. It uld be worth while to determine whether *. bitaeniorhynchus* is a vector of *W. bran- fti* in areas where *Cu. fatigans* is rare or ent. We found the densities of zoophilic *. barbirostris* to be too low to consider it as otential vector of filariasis in West Java.

SUMMARY

Twice a month, mosquitos were routinely collected for one hour after sunset off buffalo, pig and human baits, and in light traps, at a semi-urban plain site at Jakarta and at four rural West Java rice-growing sites distinctly different ecologically. Each site produced two rice crops per year. With all-night collections also being done at one of the rural sites, about 90,000 specimens representing 27 species were obtained between June 1973 and July 1974. The bait collection provided the most meaningful information, and seasonal abundance patterns were recognized for several known and potential vectors of malaria, Japanese encephalitis and filariasis (Brugian and Bancroftian).

An. aconitus was the only anopheline found in large numbers on human bait, and its highest density occurred in hilly locations with terraced ricefields. At Jakarta and an inland valley site where flat ricefields predominated, this species is practically absent. Its peak density in terraced areas was associated with the rice harvest in May and June, and most feeding on man in all night collections occurred before midnight.

Cu. tritaeniorhynchus, Cu. gelidus, Cu. fuscocephalus and *Cu. vishnui* all showed a tendency to feed on both man and pig, with *Cu. tritaeniorhynchus* the only species being quite abundant at all five study sites. Peak densities normally occurred shortly after the rice harvest. *Cu. vishnui* was the most anthropophilic among this group, although its overall density was the lowest. The Jakarta and valley sites produced the greatest numbers of potential JE vectors and the risk for human infection appeared to be greater at Jakarta where pigs were obviously more numerous. The two most abundant species biting man were *Cu. bitaeniorhynchus* and *M. uniformis.*

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